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(चौथा पुनरीक्षण)

Indian Standard

HOT ROLLED STEEL PLATE (UP TO 6 mm) SHEET AND STRIP FOR THE MANUFACTURE OF LOW PRESSURE LIQUEFIABLE GAS CYLINDERS

(Fourth Revision)

ICS 77.140.30

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

June 2008 **Price Group 4**

Wrought Steel Products Sectional Committee, MTD 4

FOREWORD

This Indian Standard (Fourth Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Wrought Steel Products Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1971 and revised in 1976, 1989 and 1999. While reviewing this standard, in the light of experience gained during these years, the Committee decided to revise it to bring in line with the present manufacturing and trade practices being followed in the country in this field.

In the present revision, the following modifications have been made:

a) Amendments No. 1, 2 and 3 have been incorporated;

b) Clause **9.1.2** has been modified;

c) Clause on Retest has been modified;

d) Requirements of dimensional and shape tolerances as given in ISO 16160 : 2005 'Continuously hot-rolled steel sheet products — Dimensional and shape tolerances' has been adopted; and

e) A clause for alternate test method specified in relevant ISO/IEC Standard has been added.

The composition of the Committee responsible for formulation of this standard is given in Annex B.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

HOT ROLLED STEEL PLATE (UP TO 6 mm) SHEET AND STRIP FOR THE MANUFACTURE OF LOW PRESSURE LIQUEFIABLE GAS CYLINDERS

(Fourth Revision)

1 SCOPE

This standard covers the requirements for deep drawing quality hot rolled steel plate (up to 6 mm), sheet and strip for the manufacture of low pressure liquefiable gas cylinders.

2 REFERENCES

The following standards contain provisions, which through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on these standards are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below:

IS No.	*Title*
228 (in various parts)	Methods for chemical analysis of steels
1599 : 1985	Method for bend test (*second revision*)
1608 : 2005	Metallic materials — Tensile testing at ambient temperature (*third revision*)
1730 : 1989	Steel plates, sheets, strips and flats for structural and general engineering purposes (*second revision*)
1956 (Part 4) : 1975	Glossary of terms relating to iron and steel: Part 4 Steel sheet and strip (*first revision*)
3803 (Part 1) : 1989	Steel — Conversion of elongation values: Part 1 Carbon and low alloy steels (*second revision*)
8910 : 1978	General technical delivery requirements for steel and steel products
10175 (Part 1) : 1993	Mechanical testing of metals — Modified Erichsen cupping test — Sheet and strip: Part 1 Thickness up to 2 mm (*first revision*)
13566 : 1992	Recommended practice of pickling by H_2SO_4 levelling and oiling of LPG sheets
IS/ISO 16160 : 2005	Continuously hot-rolled steel sheet products — Dimensional and shape tolerances

3 TERMINOLOGY

For the purpose of this standard, the following definitions in addition to those given in IS 1956 (Part 4) shall apply.

3.1 Coil — A rolled flat strip product which is wound into regularly superimposed laps so as to form a coil with almost flat side. It shall have at least 50 laps.

3.2 Micro-Alloying Elements — Elements, such as niobium, vanadium and titanium, added singly or in combination to obtain higher strength levels combined with better formability, weldability and toughness as compared with non-alloyed steel produced to equivalent strength levels.

4 SUPPLY OF MATERIAL

4.1 General requirements relating to the supply of material shall conform to IS 8910.

4.2 Hot rolled steel plates and sheets covered by this standard shall be supplied in straight lengths and strips in coils.

5 MANUFACTURE

5.1 The processes used in making the steel and in manufacturing hot rolled steel plate, sheet and strip are left to the discretion of the manufacturer.

5.1.1 However, in case sheets and strips are manufactured through thin slab casting route, the manufacturing process shall be suitably qualified on the basis of adequate data to ensure freedom from center line segregation, material inconsistency, internal cracks and poor surface quality.

5.2 The steel shall be of fully aluminum killed and non-ageing quality. It shall also pass the strainage embitterment test as given in **9**.

6 CHEMICAL COMPOSITION

6.1 Ladle Analysis

Ladle analysis of the material, when carried out either by the method specified in the relevant parts of IS 228 or any other established instrumental/chemical method, shall be as given in Table 1. In case of dispute, the procedure given in the relevant part of IS 228 shall be the referee method. However, where the method is not given in IS 228 and its relevant parts, the referee method shall be as agreed to between the purchaser and the manufacturer.

6.1.1 Alternatively the method specified in relevant ISO/IEC standard may be used.

6.2 Product Analysis

Permissible variations in case of product analysis from the limits specified in Table 1 shall be as given in Table 2.

7 TENSILE TEST

7.1 Number of Tensile Tests

Number of samples to be tested from a cast/heat, rolled or processed, shall be as follows:

a) For cast/heat size up to 100 tonne — 2 samples

b) For cast size between 100 - 200 tonne — 3 samples

c) For cast size over 200 tonne — 4 samples

The test pieces taken for tensile test shall be from the direction transverse to the direction of rolling. In case of coils, one sample shall be tested from each coil.

7.1.1 When plate, sheets and strips of more than one thickness are rolled from the same cast, one additional tensile test shall be made for each thickness.

7.2 Tensile Test

The tensile test shall be carried out in accordance with IS 1608, generally using a proportional gauge length $L_o = 5.65\sqrt{S_o}$, where S_o is the cross-sectional area of the test piece. Test pieces with a non-proportional gauge length may be used; in this case the elongation values shall be converted in accordance with IS 3803 (Part 1). The tensile strength, yield stress and percentage elongation shall be as given in Table 3.

7.2.1 Should a test piece break outside the middle half of its gauge length and the percentage elongation obtained is less than that specified, the test may be discarded at the option of the manufacturer and another test made from the sample selected representing the same cast and batch.

8 BEND TEST

8.1 Number of Bend Test

One bend test piece shall be taken from each lot of 10 tonne of material or part thereof from each cast and processed at the same time. In case of coils, one bend test piece shall be taken from each coil.

8.1.1 When plates, sheets and strips of more than one thickness are rolled from the same cast, one additional bend test shall be made for each thickness.

8.2 Bend Test

Bend test shall be carried out in accordance with IS 1599.

8.2.1 Bend test piece shall be cut so that the axis of the bend is parallel to the direction of rolling, that is, the longer axis of the test piece shall be at 90° to the direction of rolling.

8.2.2 The test piece shall be bent cold through 180°. The internal diameter of the bend for material shall be as given in Table 3. The test piece shall be deemed to have passed the test if the outer convex surface is free from cracks after complete bending.

8.2.2.1 It is sometimes difficult to ensure that the material is accurately following the radius. In case of dispute, the test piece may be pushed into a block of lead by a former of appropriate diameter.

9 STRAINAGE EMBRITTLEMENT TEST

9.1 The plates, sheets and strips shall pass the strainage embrittlement test as outlined in **9.1.2** to **9.1.5**.

9.1.1 One strainage embitterment test piece shall be taken from each heat/cast.

9.1.2 The test piece should be of adequate length and 25 mm wide, shall be so cut that the longer axis is at right to the direction of rolling. The edges of the test piece may be rounded and smoothened longitudinally to an approximately semicircular counter.

9.1.3 The test piece shall be bent cold through 90° round a former having its diameter equal to three times its thickness. This axis of the bend shall be parallel to the direction of rolling.

9.1.4 The test piece shall then be heated at 250 ± 5°C and maintained at the temperature for 15 min and then cooled in still air to room temperature.

9.1.5 The test piece shall, when straightened by hammer blows on the apex of the bend, flatten without cracking.

10 ERICHSEN CUPPING TEST

10.1 Cupping test shall be carried out for sheets and

Table 1 Chemical Composition

(*Clauses* 6.1 *and* 6.2)

Grade	Constituent, Percent					
	Carbon *Max*	Manganese *Min*	Silicon *Max*	Sulphur *Max*	Phosphorus *Max*	Aluminium *Min*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.16	0.30	0.25	0.025	0.025	0.020

NOTES

1 Elements not listed in this table may not be added intentionally to the steel. All suitable arrangements are to be made to prevent such elements being added from scrap or other materials used during manufacture, which impair the mechanical properties and usability.

2 Steel may be supplied with the addition of micro-alloying elements like niobium, titanium, and vanadium. The micro-alloying elements shall not exceed 0.10 percent when added individually or in combination.

3 The nitrogen content of the steel shall not be more than 0.009 percent. This has to be ensured by the manufacturer by occasional check analysis.

Table 2 Permissible Variations for Product Analysis

(*Clause* 6.2)

Sl No.	Constituent	Permissible Variations Over the Maximum and Under the Minimum Specified Limit, Percent *Max*
(1)	(2)	(3)
i)	Carbon	0.02
ii)	Manganese	0.03
iii)	Silicon	0.03
iv)	Sulphur	0.005
v)	Phosphorus	0.005

NOTE — Aluminium content shall not be less than 0.020 percent.

Table 3 Mechanical Properties

(*Clauses* 7.2 *and* 8.2.2)

Tensile Strength MPa	Yield Stress MPa *Min*	Percentage Elongation at Gauge Length $5.65\sqrt{S_0}$ *Min*	Internal Diameter of Bend *Max*
(1)	(2)	(3)	(4)
350 - 450	240	25	*t*

NOTE — Where '*t*' is the thickness of test piece.

strips material having a nominal thickness up to and including 3.15 mm. The test shall be carried out in accordance with IS 10175 (Part 1) for thickness up to and including 2.0 mm and in accordance with the method given in Annex A for thickness above 2.0 mm.

10.2 One cupping test shall be carried out from each lot of 10 tonne of material or a part thereof from each cast. In case of coils, one cupping test shall be carried out on each coil.

10.3 The surface of the cup shall be smooth and fracture shall not exhibit any undue directionality. The minimum cup depth shall be 13.5 mm, *Min* for actual sheet thickness range of 2.80 to 3.20 mm. For sheets/ strips of other thickness, the minimum cup depth shall be mutually agreed upon.

11 RETEST

If a test does not give the specified results, two additional tests shall be carried out at random on the same lot. Both retests shall conform to the requirements of this standard, otherwise, the lot shall be rejected.

12 FREEDOM FROM DEFECTS

The finished material shall be free from harmful defects such as seams, pipe, lamination, cracks, slivers, rolled-in-scale, blisters and pitted surface which will impair the drawability.

NOTE — When the material is supplied in the form of coils, the degree or amount of surface defects are expected to be more than in cut length sheets since the inspection of coils does not afford the same opportunity to reject the portion containing defects as with cut length. However, an excessive amount of defects may be a cause for rejection. It may be noted that hot rolled material may have some tertiary scale on the surface of the product and the presence of such scale should not be considered as surface defect.

13 DIMENSIONS AND TOLERANCES

13.1 Unless otherwise specified, the dimensions of steel plate, sheet and strip shall conform to the dimensions as given in IS 1730.

13.2 Unless otherwise specified, the dimensional and shape tolerances of steel plate, sheet and strip shall conform to the requirements as given in IS/ISO 16160.

14 CONDITION OF DELIVERY

14.1 The material may be supplied in 'hot rolled and normalized' or 'hot rolled under controlled conditions'.

NOTE — The term 'hot rolled and normalized' or 'hot rolled under controlled conditions' refer to the conditions leading to a structure and to properties typical of those for material in the normalized condition.

14.2 Subject to prior agreement between the manufacturer and the purchaser, the material may be pickled and levelled with a suitable protective treatment in accordance with IS 13566.

15 MARKING

15.1 Steel plates and sheets shall be supplied in bundles and strips in coils. The mass of the bundle or coil shall be as agreed to between the purchaser and the manufacturer. Each plate and sheet in each bundle shall be legibly marked with the cast/coil number. The top sheet in each bundle shall also be marked with the name of the manufacturer or trade-mark. Each bundle shall further carry a metal tag bearing the cast/coil number and the manufacturer's name or trade-mark or such information may be given on the top of the steel envelope containing the sheets during packing. In case of coils, each coil shall be legibly marked with the cast/coil number, grade and manufacturer's name or trade-mark.

15.2 BIS Certification Marking

The material may also be marked with the Standard Mark.

15.2.1 The use of the Standard Mark is governed by the provisions of *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A

(*Clause* 10.1)

METHOD FOR ERICHSEN CUPPPING TEST (FOR SHEET/STRIP THICKNESS ABOVE 2.0 mm)

A-1 PRINCIPLE OF THE TEST

For the purpose of the test, a specimen clamped between a holder and a die is forced into the die by a all-ended punch until fracture is seen to occur. The depth of the impression formed in this way is measured and provides an indication of the stretch forming capacity of the sheet or strip within the limit imposed by the condition of the test.

A-2 CRITICAL DIMENSIONS

The critical dimensions shown in Fig. 1 shall be observed and the tolerances indicated in Table 4 shall not be exceeded.

A-3 TESTING EQUIPMENT

A-3.1 Punch die and holder shall be sufficiently rigid to withstand the test without undergoing any appreciable deformation.

A-3.2 The penetrator should not run during the test.

A-3.3 The machine shall be such that it is possible to determine accurately the moment when the rupture commences.

A-3.4 The surface of the retaining ring and of the die in contact with the test piece shall be plane, polished and parallel to each other and perpendicular to the axis of movement of the penetrator.

A-3.5 The dimensions and tolerances shall comply with those as shown in Fig. 1. The distance from the axis of the die to the center of the spherical part of the penetrator shall be less than 0.1 mm throughout the range of travel in use.

A-3.6 The working surface of the penetrator shall be spherical and only this spherical portion shall be in contact with the test pieces during the test.

A-3.7 The Vickers hardness of the working surface of die, the retaining ring and the penetrator shall be at least 750 HV.

A-3.8 The working surface of the penetrator shall be polished.

A-4 TEST PIECE

A-4.1 The test piece shall be flat and of such dimensions that the centre of any indentation is not less than 45 mm from any edge of the test piece, and not less than 90 mm from the centre of the nearest indentation where the dimensions of the product permit.

A-4.2 The cutting of the test piece shall not produce burr or distortion on the edge, which would interfere with it being placed in the apparatus. The test piece before test shall not be submitted to any hammering or hot or cold working.

A-5 TEST PROCEDURE

A-5.1 The test shall be carried out at room temperature.

A-5.2 Measuring the Thickness of the Specimen

The thickness of the specimen shall be measured to the nearest 0.01 mm.

A-5.3 Lubrication

Prior to testing, both sides of the specimen and the punch should be lightly lubricated with graphite grease. Recommended characteristics of the grease used for the testing machine are similar to as recommended in Annex of IS 10175 (Part 1).

A-5.4 Holding Force

A holding force of approximately 10 kN is to be applied to the specimen between the die and the holder.

A-5.5 Cupping

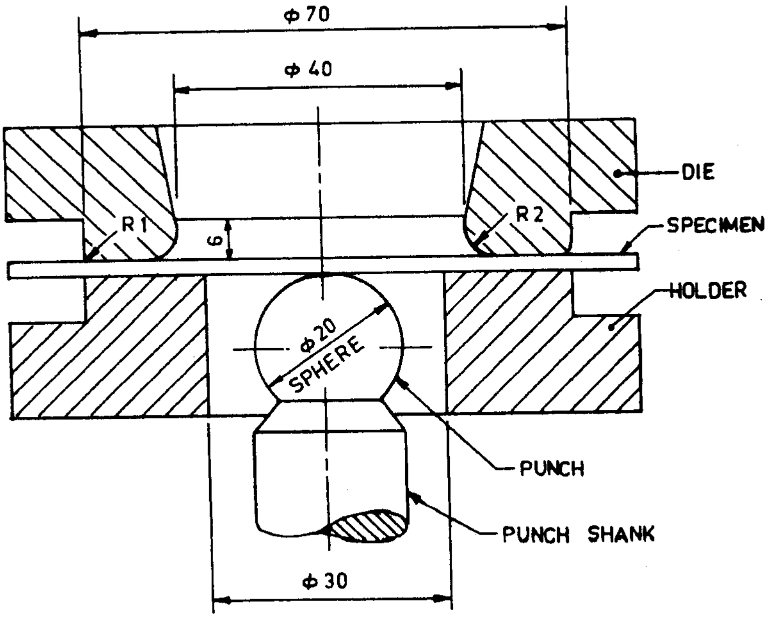
The punch should be brought into contact with the specimen in such a manner as to avoid any sudden impact, thereby determining the starting point for measuring the depth of cupping. The specimen is then cupped by causing the punch to advance with a uniform feed at a rate between approximately 5 and 20 mm/min until fracture occurs. Towards the end of the test, the rate of punch advance should be near the lower limit specified. At the instant of fracture, the depth of penetration of the punch is determined.

A-5.6 Definition of Rupture

The rupture is deemed to have taken place when the material is disrupted right through its thickness. In general, the rupture is accompanied by a drop in the load sustained by the specimen and often also be a perceptible noise. The drop in load sustained may, therefore, be regarded as a sign that the test has come to an end.

A-6 TEST RESULT

Erichsen depth nearest to 0.1 mm is taken as the depth of penetration of the punch in mm at the instant of rupture.



All dimensions in millimetres.

FIG. 1 DIE HOLDER AND PUNCH OF CUPPING MACHINE

Table 4 Permissible Deviation of Major Dimensions

(*Clause* A-2)

Part (1)	**Dimension** (2)	**Tolerance, mm** (3)
Punch	Diameter of ball end	—
Die	Diameter of bore	± 0.05
	Radius of inner edge	
	External diameter	
Blank-holder	Internal diameter	± 0.1
	External diameter of clamping surface	

ANNEX B

(*Foreword*)

COMMITTEE COMPOSITION

Wrought Steel Products Sectional Committee, MTD 4

Organization	*Representative(s)*
Tata Steel Ltd, Jamshedpur	Dr D. Bhattachrjee (***Chairman***) Shri Indranil Chakraborty (*Alternate* I) Dr A. N. Bhagat (*Alternate* II)
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Escorts Knowledge Management Centre, Faridabad	Shri Alok Nayar
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SAIL, Research & Development Center for Iron & Steel, Ranchi	Dr S. K.Chaudhuri Dr B. K. Panigrahi (*Alternate*)
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Steel Re-rolling Mills Association of India, Mandi Gobindgarh	Representative Shri H. D. Khera (*Alternate*)
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